

Summary of Missouri Culvert Studies

History

Since the early 1930's, MoDOT has continued to conduct various studies to monitor and evaluate the durability and performance of culvert pipe materials used in Missouri. Earlier studies investigated and compared the performance of zinc-coated corrugated steel pipe (CSP) and reinforced concrete pipe (RCP). These studies concluded that CSP had a predicted life of less than 50 years and that RCP would approach 100 years. A study conducted in the 1980's indicated similar conclusions. Despite its lower, initial installation cost, CSP most likely would have to be installed one to four times during the life of one RCP. The study also evaluated the effectiveness of various coatings for steel or metal pipe, including epoxy, bituminous, polymer, and aluminum (known as aluminized). Aluminum was found to be the only coating indicated to be equal to the galvanized (or zinc) coated pipe.

A report written in 1991, Life Expectancy Determination of Zinc-Coated Corrugated Steel and Reinforced Concrete Pipe Used in Missouri, indicated that CSP had a service life of approximately 44 years in Missouri and that service life for RCP could not be predicted due to an insufficient number of RCP having deteriorated. It was stated, however, that the service of life of RCP would be significantly higher than CSP. The report also indicated that attempts to relate pipe service life to measurable environmental parameters such as pH, abrasion, soil resistivity, chemical characteristics of the effluent, and watershed characteristics proved unsuccessful. The results showed that neither a single nor combination of measurable parameters were found to exist, which would predict the service life of pipe placed anywhere in the state. Lastly, the report recommended the investigation of plastic or fiberglass pipe liners and also the investigation of pipe materials other than those considered in the study.

A more recent report written in 1995, Performance Evaluation of Aluminized and Galvanized Steel Culverts, provided conclusions to a study involving a direct comparison of the performance of aluminized (aluminum coated) culvert sections to galvanized culvert sections, which had been installed at specific locations in 1952. The report conclusions indicated that aluminized culverts have a longer life expectancy than galvanized culverts in similar environments.

The most recent on-going research efforts to determine the performance and service life of pipe materials used in Missouri include the establishment of an inventory database in 1987 to track the type, location and service life of culverts installed and the 1991 initiation of a study to evaluate various in-place pipe materials. This study consists of a biannual investigation of 230 culverts located in seventy-one counties. Some of the culvert materials evaluated include polyethylene (single and double walled), aluminum, aluminized, polyvinyl chloride (PVC), reinforced concrete (RCP), and various pipe liners.

Performance Issues

Depending upon the type of pipe material placed, there are number of factors which influence performance. Metal pipes are highly susceptible to corrosion, which is induced

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as a result of the surrounding conditions of the pipe. For example, soil resistivity, temperature, soil or water pH, soil or backfill chemistry, ground or surface water chemistry, and the adjoining of dissimilar metals are some of the factors that can cause corrosion of metal pipe. A majority of the metal or steel pipe failures in Missouri can be attributed to corrosion. Concrete pipes are susceptible to corrosion due to exposure to a low pH or the presence of sulfates in soil or water. To date, there have been no such problems reported with RCP installed in Missouri. Pipes placed in mining areas carrying acid or acid-forming compounds, specifically from coal cinders, can induce chemical attack in both metal and concrete pipe. There have been some reported problems of this nature in Missouri, for example, requiring replacement of RCP in locations of mining operations. Polyethylene or plastic pipes are highly resistant to corrosion, and hence, might be more desirable to install in known, highly corrosive environments, from a corrosion standpoint.

Performance can also be affected by abrasion created by the movement of sands, aggregates or other debris in water flowing through a pipe, which can cause deterioration of pipe surfaces, especially pipes having protective coatings. The structural strength of pipe materials is another performance issue. Steel is known to have a high initial strength, but once it begins to corrode or deteriorate, its structural capacity then becomes threatened. While concrete pipe has significant structural strength, some problems have occurred in Missouri with disjuncting of in-place RCP sections. A concern with plastic pipe is strain and creep of the pipe itself, which is known to occur with thermoplastic type materials under sustained loads. Plastic pipe is also susceptible to fire damage and ultra-violet (UV) degradation. Some manufacturers now add carbon black to the resin material used in plastic pipes to inhibit UV degradation. Lastly, mower damage problems have been reported to occur to both plastic and metal pipes.

Current Research Results

A statistical analysis of the data incorporated into the culvert inventory database to date found that the average life of CSP installed from 1910 to 1939 was approximately 60 years. However, CSP installed from 1940 to 1998 only indicated a service life of approximately 40 years. According to its manufactures, plastic pipe, particularly high density polyethylene (HDPE), is claimed to have a service life of 75 years. Missouri has only used HDPE since 1983 and with plastic pipe being a relatively new industry since the 1960's, actual service life cannot yet be determined. Reinforced concrete pipe has been used extensively for approximately 75 years in Missouri with little failures. Although a determination of actual service life for RCP

cannot yet be made in Missouri, current observations of performance indicate that RCP will most likely last well beyond 75 years.

In addition to tracking the performance of various in-place pipe materials, the 1991 culvert study also made attempts at correlating pipe field performance and service life to field testing, such as pH and soil resistivity. The results proved inconclusive at showing any relationship of environmental parameters to service life and, thus, confirmed conclusions made in the 1991 report.

Conclusions

After many years of monitoring pipe performance in Missouri, some general conclusions can be drawn:

- CSP (galvanized/zinc-coated) installed after 1940 has shown a service life of approximately 40 years. CSP installed prior to 1940 lasted approximately 60 years.
- Aluminized (aluminum coated) culverts have demonstrated a longer life expectancy than galvanized in similar environments.
- RCP has shown to be more durable and significantly outlasts CSP. RCP appears to be more-cost effective, despite the lower, initial installation cost of CSP.
- To date, RCP has demonstrated a service life of, at least, approximately 75 years, and observed performance indicates that RCP will most likely last well beyond 75 years.
- Polyethylene (plastic) pipe has been installed in Missouri since 1983 and continues to perform.
- Efforts to correlate pipe field performance and service life to measurable environmental parameters such as pH, abrasion, soil resistivity, chemical characteristics of the effluent, and water shed characteristics have consistently proved unsuccessful.

Tracking and monitoring the performance of the different pipe materials used throughout Missouri is felt to be a worthwhile effort. With new materials emerging in more recent years, such as polyethylene pipe materials and pipe liners, it's important that continued evaluations take place so that a determination can be made with regards to the most cost-effective pipe installation, given the location and conditions.

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